Prepared Statement
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Mr. Chairman and Members of the Subcommittee, thank you for your invitation to appear before the Subcommittee today. I am honored by your request to share with you the work that my colleagues and I have been doing to understand the possible economic impacts of the Kyoto Protocol and to reconcile our estimates with those that have been made by the Administration. I believe that understanding how responsible professionals can arrive at sharply different estimates of the same phenomenon is important. Furthermore, I believe that I will be able to convince you that the discrepancies between Dr. Yellen's analysis and the analysis my colleagues and I have done can be explained by honest and understandable differences in key assumptions. I will detail these assumptions and leave it to you to determine which are the most reasonable.

My testimony will be organized around five topics:

- How Dr. Yellen reached the conclusion that costs will be "$7 to $13 billion," and what the starting point for her estimates must have been;

- How the measure of costs used in Dr. Yellen's testimony understates the full cost to the economy *even under her own assumptions;*

- *Why* the language of the Kyoto Protocol and the positions of other countries on emissions trading make it necessary to consider assumptions that are far less optimistic than those underlying Dr. Yellen's testimony;

- How other assumptions in Dr. Yellen's testimony give an optimistic bias to her estimates; and finally,

- I will contrast the costs estimated under Dr. Yellen's optimistic assumptions to estimates under alternative assumptions that also represent realistic possibilities. To do this I will use a methodology that reproduces Dr. Yellen's results under her assumptions. Under different and reasonable assumptions, the costs of the Kyoto agreement would be ten times higher than the range stated by Dr. Yellen.

In her testimony before the House Commerce Committee on March 4, 1998, and subsequently. Dr. Yellen stated that, with full global emissions trading and a number of other assumptions, the cost of the Kyoto Protocol would be "S7 to S13 billion" in 2010, and prices of carbon emissions permits would be in the range of "S14 to $23 per ton." Based on the content of her previous testimony, it is possible to reconstruct the analysis behind Dr. Yellen's cost estimates and to infer what her estimates of the cost of the Kyoto agreement would be under less optimistic assumptions about international emissions trading.

Assumptions underlying the Administration's estimates

In her testimony, Dr. Yellen stated that her estimates came from three sources. The starting point was the "Second Generation Model" (SGM) developed at Pacific Northwest National Laboratories (PNL). I am quite familiar with the SGM. Its creator, J. A. Edmonds, and I have been friends for many years. We have participated together in many workshops of the UN Intergovernmental Panel on Climate Change and the Stanford Energy Modeling Forum over the years. Dr. Edmonds wrote a clear and complete paper using the SGM to analyze the Kyoto agreement last October. The other two sources of Dr. Yellen's estimates are an assumption about what the United States will be able to convince other countries to agree to in the area of international emissions trading, and an assumption that there will be large reductions in energy use at no cost. These reductions in energy use are over and above the large improvements in energy efficiency already built into the SGM forecast for 2010.

I conclude that if the reductions in the price of carbon permits that Dr. Yellen attributes to international emissions trading and costless improvements in energy efficiency were removed, her estimates of the cost of carbon permits would be S 153 per ton, and direct costs in 2010 would be $42 billion. The results are fully consistent with published results from the SGM. My reconstructed calculation, using the percentage cost reductions that Dr. Yellen attributes in her testimony to Annex 1 trading, global trading, and costless improvement in energy efficiency, is displayed in Table-1 .

Table 1: Reconstruction of Starting Point for Administration Cost Estimates

Assumption	% Saving	Cumulative% Saving	Direct Cost (SGM Formula)	Carbon Price ($/Metric Ton)
No Trading			$42B	$153/T
Annex B trading	50%	50%	$31B	$76/T
Global Trading	50%	75%	$18B	$38/T
Free Efficiency	40%	85%	$12B	$23/T

Source: CRA calculations based on 3/4/98 testimony and direct cost formula from "Return to 1990: The Cost of Mitigating United States Carbon Emissions in the Post-2000 Period", J.A. Edmonds, et al., October 1997.

This table shows, without any other changes in Dr. Yellen's assumptions, how important her optimism about costless improvement in energy efficiency and international emissions trading is. Her estimates under an ideal emissions trading regime involving just Annex I countries would be a direct cost of $3 1 billion and a cost for emission permits of $76 per ton. I have used full Annex B trading in this calculation rather than the "Double Bubble" or "Double Umbrella" in which European countries are excluded from access to low-cost Russian emissions permits, because that scenario is so disadvantageous to Europe that I cannot believe they would agree to it.

Incomplete measurement of costs

The definition of "costs" used in Dr. Yellen's testimony and in the "Second Generation Model" on which it relies is incomplete. She provides estimates of what she calls "direct cost" -- measured as the cost in energy markets of switching fuels and investing in energy conservation plus the cost of purchasing permits from other countries. However, this measure ignores the ripple effects of higher energy costs in other sectors of the economy, as well as the dynamic effects of higher costs, reduced competitiveness, reduced profits, and reduced incomes on investment.

At CRA, we have had considerable experience over the years in comparing so-called "direct costs" to the full impact of regulatory programs on the economy. In work by Kopp and Hazilla at Resources for the Future, studies of the costs of air quality regulations by Jorgenson and Wilcoxen, and studies of energy taxes by Goulder, Jorgenson, and Wilcoxen in addition to our own work, there emerges a consistent pattern. In all these studies, the full impact on GDP exceeds the direct cost of a regulatory program or tax by a factor of 2 to 4.

Table 2: Comparison of CRA and SGM: No Trading, 1990 Emissions Limit in 2010

	SGM	CRA BASE	CRA ADJUSTED*
CARBON TAX ($/METRIC TON)	**108**	**213**	**109**
EMISSIONS REDUCTION (MILLIONS OF METRIC TONS)	400	370	370
DIRECT COST ($BILLION)	20	39	20
GDP LOSS ($BILLION)	NA	-120	-55

Source: CR4 Multi-Region Trade Model and "Return to 1990: The Cost of Mitigating United States Carbon Emissions in the Post-2000 Period", J.A. Edmonds, et al., October 1997.

*"CRA Adjusted" refers to running CRA's MRT model under Dr. Yellen's assumptions.

Table 2 compares our estimates of direct cost and full GDP loss to estimates from the SGM for a comparable scenario. Note that this is not the Kyoto Protocol, but comes from an earlier study of the cost of limiting emissions to 1990 levels. The important point is that when we change one parameter in our model so that we are estimating the same carbon price as SGM, we calculate the same direct costs but a total GDP loss almost three

times larger. Based on these proportions, just changing the definition of costs used by the Administration from "direct cost" to the more complete "loss in GDP." and keeping all the rest of the optimistic assumptions would increase costs from "$7 to S 13 billion" to "$20 to $38 billion."

Opposition to unrestricted emissions trading

A number of other signatories to the Framework Convention on Climate Change have stated their strenuous opposition to key elements of the U.S. position on emissions trading: they object to inclusion of developing countries and to allowing Russia and other countries to sell unneeded emissions credits. These parties have proposed tight restrictions on how much of a country's obligation to reduce emissions can be satisfied through purchasing credits. Indeed, the developing countries made sure that the Kyoto Protocol does not even allow them to join in the permit trading system. These positions make it necessary to consider the possibility of outcomes in which emissions trading is seriously constrained. I believe that decisionmakers need to be informed about the full range of risks the United States faces from the Kyoto Protocol, including estimates of costs under less favorable assumptions about what other countries will agree to.

Other assumptions that reduce costs

There are several other areas in which the assumptions in Dr. Yellen's testimony are quite optimistic. Three are very important: first, the United States will be given enough credit for growth in carbon sinks to significantly reduce its obligation to cut carbon dioxide emissions; second, in just 12 years, the announcement of the Kyoto agreement and the minimal programs proposed by the Administration will produce an additional 40% reduction in energy use at no cost; and third, utilities will be able switch all of their existing coal-fired powerplants to natural gas by 2010. We, and many other analysts, have made different assumptions in these areas.

The whole subject of carbon sinks and other greenhouse gasses remains unsettled, both scientifically and in the negotiations. In our work, we made the neutral assumption that sinks will neither increase nor decrease the percentage reduction required in carbon dioxide emissions, rather than the optimistic assumption that they will reduce the obligation.

Dr. Yellen states that her baseline forecast for emissions in 2010 already incorporates an assumption of a 1% annual improvement in energy efficiency. This means that energy use will grow at just over half the projected rate of growth in GDP. Dr. Yellen assumes that there will be an additional 40% improvement in energy efficiency over the next 12 years at no cost, and attributes this improvement to a "25% increase in the annual rate of efficiency improvement." I believe that there is a mathematical error here, or something has been left out in the justification of the 40% improvement. Increasing the annual rate of efficiency improvement from 1% to 1.25% gives only a 4.5% improvement in energy efficiency over 12 years, not 40%. This is a simple compound interest calculation.

Even a costless 1% annual improvement in energy efficiency exceeds the rate chosen by most forecasters, including PNL and the Energy Information Administration, and the rate based on our historical experience with energy conservation. At the very least, the 40% improvement is a highly optimistic assumption that has no clear justification, and should be balanced by a case with more conventional assumptions.

Finally, the SGM model, which provides Dr. Yellen's starting point, makes a critical assumption about fuel switching in electric utilities. The SGM is able to limit the carbon price to $150 per ton or less by assuming that electric utilities will be able to convert almost all their existing coal-fired powerplants to natural gas by 2010 at a cost of about $100 per ton, and that the price of carbon permits cannot go above this level until nearly all the existing coal is driven out of electric power-plants. I have serious doubts about whether the utility industry can or will make such a massive shift in just 12 years, or that the national economy would tolerate the disruption of the coal industry. Again, a balancing assumption that is less optimistic is needed to understand the full range of possible costs.

How large could costs be?

Finally, I would like to compare the results of our analysis using the CRA Multi-Region Trade model with those in Dr. Yellen's testimony. First, I would like to make it clear that her assumptions do lead logically to her conclusions and that under her assumptions our model gets very similar results for carbon prices and direct costs. This comparison is provided in Table 3.

Table 3: Comparison of Results – CRA and Yellen under Yellen Assumptions

	CRA			YELLEN	
	GDP % Loss	**Direct Cost**	**Price**	**Direct Cost**	**Price**
NO TRADING	-0.67	$41B	$150/T	$42B	153/T
ANNEX B	-0.54	$28B	$68/T	$31B	76/T
GLOBAL	-0.37	$14B	$30/T	$18B	38/T
GLOBAL with 1.25% AEEI	-0.35	$13B	$29/T	$12B	23/T

Source: CRA Multi-Region Trade Model and calculations based on Dr. Yellen's 3/4/98 testimony.

As Table 3 shows, when we introduce all of Dr. Yellen's assumptions into our model, we get nearly the same estimates of permit prices and direct costs as a starting point. t these estimates are at the extreme optimistic end of the range. The first necessary correction is to shift to a measure of the full impact on the economy, not just direct cost. Estimates of GDP loss, in our model and virtually any other complete model of the economy that could be applied to the problem, are more than twice the estimates of direct cost provided by Dr. Yellen. Table 4 displays our estimates of the economic impacts of the Kyoto agreement under different international trading regimes, and our assumptions, and compares them to results our model would give under the Yellen assumptions. The

only Yellen assumption not adopted in these calculations is an additional 40% saving from costless energy conservation.

Table 4: CRA Results for Limited Emissions Trading

	CRA Assumptions		YELLEN Assumptions	
	GDP	Price ($/tonne)	GDP	**Price** ($/tonne)
NO TRADING	**-1.37%**	**277**	**-0.67%**	150
ANNEX B -- no hot air	**-1.15%**	**155**	**-0.62%**	**86**
ANNEX B	-1.01%	**119**	**-0.54%**	**68**
GLOBAL	**-0.59%**	**48**	**-0.37%**	**30**

Source: CRA Multi-Region Trade Model.

Under a scenario in which trading among Annex I countries is allowed but under terms now being insisted on by other countries, and in which different assumptions are made about costs of emissions reduction in the United States, costs would be ten times as large as Dr. Yellen estimates. This scenario is less optimistic than Dr. Yellen's but perfectly reasonable: it assumes that credit for sinks is calculated in a way that is less favorable to the United States, developing countries do not participate in international emissions trading; Russia is allowed to sell only permits generated by reducing emissions below baseline levels; utilities are not able to replaee a large fraction of their coal-fired powerplants with natural gas by 2010; and the costless improvements in energy efficiency that Dr. Yellen assumes do not materialize. Under these assumptions costs in 2010 would be about 1.15% of GDP, or over $100 billion in 2010, and carbon prices would be about $155 per ton. The outcome could be even more costly if Russia restricts its sales of permits to take advantage of its position as the sole seller under Annex B trading, or if the inflation caused by higher energy prices results in a tightening of monetary policy and a further slowdown of its economy.

Mr. Chairman, as you know, I was invited to appear before you very recently. I am in the final stages of editing a report that explains and documents more completely the points that I have made in this testimony. I have outlined our conclusions to provide a basis for discussion of these issues today. I would appreciate your holding the record open so that I could expand my statement and provide you with a copy of that full report.

By and large, the approach to analyzing the impacts of Kyoto that Dr. Yellen has presented is consistent with ours and the mainstream of economic analysis. The exceptions have to do with the completeness of the measure of cost used by Dr. Yellen and the CEA and their inclusion of a large measure of costless improvement in energy efficiency. Furthermore, Dr. Yellen and the Administration make a number of assumptions that appear to be excessively optimistic. Changing these assumptions to make them more realistic produces an estimate very close to ours.

Thank you again for asking me to appear before you to discuss these important economic issues. This concludes my prepared statement. I will be happy to answer your questions.